# TM 8-293

WAR DEPARTMENT TECHNICAL MANUAL

# PHYSICAL THERAPY FOR LOWER-EXTREMITY AMPUTEES



*WAR DEPARTMENT* • *JUNE 1946*

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*T M8 - 293*

*This manual supersedes TB MED 122, December 1944.*

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*WAR DEPARTMENT • JUNE 1946*

*United States Government Printing Office*
*Washington: 1946*

WAR DEPARTMENT
Washington 25, D. C., 14 June 1946

TM 8–293, Physical Therapy for Lower-Extremity Amputees, is published for the information and guidance of all concerned.

[AG 300.7 (18 Jan 46)]

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For explanation of distribution formula see FM 21–6.

Acknowledgment is made to the American Physiotherapy Association for the use of Table II, Comparative Muscle Grading Table.

# CONTENTS

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# CHAPTER 1
# INTRODUCTION

## Section I. GENERAL

### 1. Purpose

This manual is concerned with the role of physical therapy in "management" of amputees. Management encompasses more then surgery, healing processes, restoration of function, and fitting of artificial limbs. It also takes cognizance of the number of persons who have lost limbs, the dramatic circumstances surrounding the injuries, the psychic trauma of amputation, and the necessity for physical and social adjustment. For this reason treatment for amputation is not considered as specific, but rather as a continuous process which begins on the battlefield or scene of injury and concludes with discharge of the patient from an Army hospital after he has been properly fitted with an artificial limb and educated in its use.

The purpose of this manual is to present a standardized program for physical therapy management of lower extremity amputations.

### 2. Scope

*a.* The objectives of physical therapy in the treatment of amputations are:

(1) To shrink and toughen the stump.

(2) To give muscle and postural examinations to determine existing defects in regard to muscle weakness, contractures, and faulty segmental alignment of the body as a whole.

(3) To maintain or restore normal range of motion and muscle strength of the affected extremity.

(4) To correct the existing defects before the amputee is fitted with his prosthesis.

(5) To instruct the lower-extremity amputee in correct technique of walking, making turns, climbing stairs, picking up objects, etc.

*b.* Bandaging and therapeutic exercise have been invaluable in accomplishing these objectives. Other forms of physical therapy such as massage, hydrotherapy, thermotherapy, ultra-violet irradiation, and common ion transfer have been employed extensively at times, but they must be individually prescribed and administered. Bandaging and therapeutic exercise, on the other hand, are applicable in the case of nearly every lower-extremity amputee; therefore they will be dealt with in detail in this manual.

## Section II. ADMINISTRATION

### 3. Personnel

For the very reason that treatment for amputation is a continuous process, the utmost cooperation must exist among the several persons and departments interested in management of a patient. The medical officers, ward personnel, physical therapists, occupational therapists, various members of the reconditioning service, and the technicians from the artificial limb shop must work together closely if the program is to succeed.

### 4. General Procedures

To further cooperation in the course of treatment certain procedures must be agreed upon and adhered to:

*a.* Except in emergencies, furloughs will not be granted a patient until it can be certified that he can satisfactorily manage his prosthesis (graduation from Intermediate Walking Class). This will insure that no important treatment is interrupted.

*b.* No amputee should begin walking with his prosthesis until approval has been given by the chief of the amputation section and the physical therapy section.

*c.* When a prosthesis has been finished it should be delivered to the physical therapy section and kept there until the patient has completed the beginning phase of walking instructions and has been checked by the chief of the amputation section, or some person he may designate. Only then is the patient allowed to keep his prosthesis on the ward.

*d.* All walking instruction will be under the supervision of the physical therapy section.

(1) A record system showing the current status of every amputation case in relation to the walking program will be maintained in the physical therapy section.

(2) Cases will be divided into four groups for instructions; unilateral below-knee amputee (B/K), unilateral above-knee amputee (A/K), amputees fitted with tilting-table prostheses (tilting tables; this category includes patients with disarticulation of the hip joint or thigh amputation too short for fitting with an ischial bearing thigh bucket, that is, stumps less than 3 inches long), and bilateral amputees.

The instruction groups will be as small as possible so that instruction may be given on an individual basis. Classes 30 minutes in length will be conducted by physical therapists especially trained for the program. Each patient will receive a proportionate share of instruction.

*e.* Arrangements should be made for a designated time every 2 days when a qualified orthopedic mechanic SSN 366 (limb fitter) can meet with the physical therapist in charge of walking instructions and patients whose prostheses need readjustment.

*f.* A 16-millimeter movie camera with projector, screen, and other necessary photographic equipment should be assigned to the physical therapy section. Sufficient technical personnel from the local Signal Corps or other photographic unit should be placed at the disposal of the physical therapy section so that moving picture shots can be taken showing each emputee at the beginning of his walking program and recording his progress thereafter.

About 100 feet of film should be exposed at each photographic recording to demonstrate:

(1) *Full figure* walking toward the camera, executing a turn, and walking away from camera.

(2) *Lateral full figure* with each side toward the camera in turn.

(3) *Close-up of lower extremities* during walking.

(4) *Standing* for lateral and posterior plumb line tests.

The physical therapist will analyze these pictures, then show them to the amputee, at the same time pointing out defects in posture, coordination, or walking; noting improvement; and insuring that the pictures are utilized as much as possible from the instructional viewpoint.

*g.* No amputee will be discharged from the service until he has completed the walking program outlined for him.

# CHAPTER 2

# BANDAGING

## Section I. GENERAL INSTRUCTIONS

### 5. Bandaging Technique

*a.* Correct bandaging of a stump is an important part of the physical therapy treatment in insuring proper healing and shrinkage.

After exercise, the stump must be bandaged firmly with as many bandages as necessary to give even pressure throughout. *Bandaging must be repeated several times daily* for the patient to derive maximum benefit. The bandage is worn continuously until the patient is fitted with his prosthesis; and for 5 or 6 months after fitting, whenever the prosthesis is removed.

Incorrect bandaging will *harm* the stump. Common errors to be avoided are:

(1) Exerting a constricting effect. This may produce edema distal to the site of the compression.

(2) Undue general tightness, especially at the edges of the bandage where there is less elasticity than in the center. This error must be especially guarded against by beginners who in striving for neat appearance of the bandage cause constriction.

(3) Bandaging unhealed stumps too snugly. Bandaging should be less snug than for healed stumps. Persistence of this error will delay healing.

*b.* The bandage stump should have a smooth, even contour without bulges.

Four safety pins placed or spaced in diamond shape to secure the cross-wrappings of the hip spica (par. 7) at the lateral side of the hip should prevent a certain amount of shifting or crawling of that part of the bandage.

### 6. Care of Bandages

Because of their elastic qualities, ace type bandages are most suitable for bandaging stumps. These bandages contain no rubber, but are made of a soft, porous-weave cotton which must be laundered carefully to retain the elasticity necessary for proper application.

The bandage should be washed with mild white soap and water. All soap particles should be removed by through rinsing. Since the bandages will lose their elasticity if hung, they should be spread on a clean, flat surface until dry, than rolled evenly and firmly without stretching.

## 7. Thigh Stump

Application of bandages in thigh amputations is especially difficult and requires patience and practice in technique.

*a.* Two 4-inch ace bandages sewed together end to end make a satisfactory bandage for the average thigh stump. The 6-inch bandage is recommended for larger stumps.

*b.* A firm, even pressure must be maintained throughout the whole bandaging procedure. The bandages should be applied as firmly as the patient can tolerate without pain or circulatory interference. Application is slightly tighter at the distal end of the stump than at the proximal end.

*c.* The bandage is applied as follows (see FS 8–85):

*Figure 1.*

(1) Begin with the bandage at the groin where it is held by the patient's thumb. (See fig. 1.)

*Figure 2.*

(2) Proceed over the end of the stump to the upper thigh, posteriorly, where the bandage is held by the patient's fingers. (See fig. 2.)

*Figure 3.*

(3) Return bandage over end of stump, laterally. (See fig. 3.)

*Figure 4.*

(4) Again over end of stump, medially. Each recurrent is held like the first. (See fig. 4.)

*Figure 5.*

(5) Having completed three recurrent turns, begin the anchoring turn by drawing the bandage laterally from the posterior aspect to the lateral side of the stump. (See fig. 5.)

*Figure 6.*

(6) Encircle, carrying the bandage high in the groin. (See fig. 6.)

*Figure 7.*

(7) Begin spiral to stump by carrying the bandage from the lateral thigh toward the medial side of the stump. Continue spiral, encircling stump twice. Then turn patient on his side. (See fig. 7.)

*Figure 8.*

(8) From the posterior thigh, carry the bandage over the lateral side of the hip, and continue over the crest of the ilium, across the abdomen. (See fig. 8.)

*Figure 9.*

(9) Continue around lower hip. (See fig. 9.)

*Figure 10.*

(10) Return to stump. (See fig. 10.)

*Figure 11.*

(11) Encircle stump, completing first spica. Begin second spica, following the course of the first. Return to stump and continue spirals to complete bandage. (See fig. 11.)

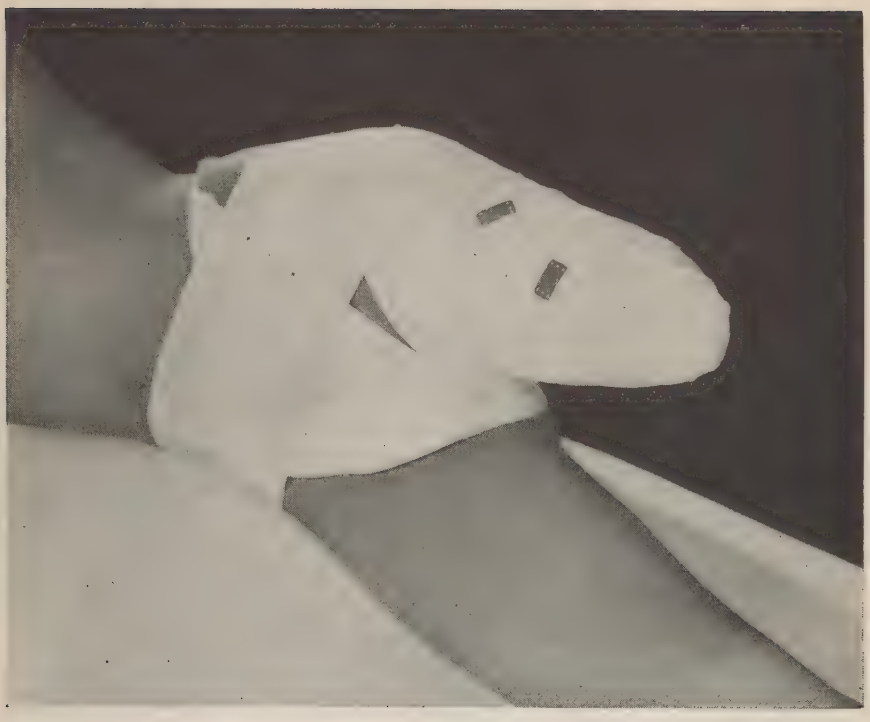


*Figure 12.*

(12) Bandage is completed. (See fig. 12.)

## 8. Leg Stump

Apply and anchor the three recurrents as demonstrated in figures 1 through 6 for the thigh stump.

Then secure the bandage by passing it to one side above the patella, encircling the lower thigh twice, and returning on the opposite side of the patella to the stump. The patella is left exposed.

## 9. Self-Bandaging

Each patient should be taught to bandage his own stump as soon as possible. All amputees who are ambulatory and who are going to the physical therapy section should be bandaged once a day under the guidance of the physical therapist and be instructed to reapply the bandage themselves as often as necessary. Group instruction may be given to save time.

Someone must secure the bandage for the thigh amputee when he does recurrent turns over the end of his stump in applying his own bandage. He should be taught to elevate his pelvis with his good leg so that his stump is held in extension when he applies the spica to his waist.

*Table I.*

## BODY MECHANICS EXAMINATION CHART FOR LOWER EXTREMITY AMPUTEES

| Name | | Ward number |
|---|---|---|
| Height | Weight | Age |
| Site of amputation | | Right, left, or bilateral |
| Handedness | | Date physical therapy started |

### PART I. PRE-PROSTHETIC AND POST-PROSTHETIC TESTS

*Tests for Flexibility*

| | Pre-op. Date | Post-op. Date | Post-Pros. Date |
|---|---|---|---|
| Forward Flexibility Test: | | | |
| (Record in inches) (If limited, note whether hamstring or back muscles). | | | |
| Extensibility Test: | | | |
| (Normal, fair, or poor) | | | |

| LEFT | | | *Tests for Contractures (Record in Degrees)* | RIGHT | | |
|---|---|---|---|---|---|---|
| Post-Pros. (Date) | Post-op. (Date) | Pre-op. (Date) | | Pre-op. (Date) | Post-op. (Date) | Post-Pros. (Date) |
| | | | Gastroc-soleus | | | |
| | | | Hamstrings | | | |
| | | | Hip flexors | | | |
| | | | Hip abductors | | | |
| | | | Pectorals (sl. mod. or mark.). | | | |

| LEFT | | | *Tests for Muscle Strength (Record by Percentage)* | RIGHT | | |
|---|---|---|---|---|---|---|
| Post-Pros. (Date) | Post-op. (Date) | Pre-op. (Date) | | Pre-op. (Date) | Post-op. (Date) | Post-Pros. (Date) |
| | | | "Upper" anterior Abdominals: (Trunk-raising test). | | | |
| | | | "Lower" anterior Abdominals: (Leg-raising test)*. | | | |
| | | | Hip flexors | | | |
| | | | Hip ext. rotators | | | |
| | | | Hip int. rotators | | | |
| | | | Tibialis posticus | | | |
| | | | Long toe flexors | | | |
| | | | Gluteus, medius (post. part). | | | |
| | | | Hip adductors | | | |
| | | | Hip abductors | | | |
| | | | Lateral abdominals | | | |
| | | | Hip extensors | | | |
| | | | Hamstrings | | | |
| | | | Back extensors | | | |
| | | | Quadriceps | | | |

| Signature of physical therapist | Date |
|---|---|

* If test performed with prosthesis, record results with asterisk.

## PART II. POST-PROSTHETIC TESTS

*Tests for Posture*

*Segmental alignment:*

| | | |
|---|---|---|
| _____Normal alignment | _____Lordosis | Pronated foot |
| _____Forward head | _____Int. rotated femur | _____ |
| _____Kyphosis | _____ | _____ |

Other defects_____

*Lateral pelvic alignment:*

_____Level High on_____side.

*Plumb Line Test for Anteroposterior Alignment* (Hung in line with point anterior to lateral malleolus).

| | |
|---|---|
| _____Normal | _____Body ant. to Plumb line |
| _____Good except Lordosis | _____Pelvis ant. to Plumb line |
| _____Good except Forward Head | _____Other deviations |

*Plumb Line Test for Lateral Alignment* (Hung from point midway between heels placed 3″ apart).

| | |
|---|---|
| _____Normal | _____Displacement of trunk to right |
| _____Scoliosis | _____Displacement of trunk to left |

*Test for Causes of Improper Gait*

LIMP

_____Type
_____Cause

Recommendation for Correction:

_____Special exercises
_____
_____Special Walking Instruction
_____
_____Prosthesis Correction
_____
_____Shoe Correction
_____

SUMMARY NOTE. For classification of amputees into special groups for Physical Therapy treatment

1. Patient shows no defects in body mechanics and is ready for walking_____.
2. Patient requires special exercise to correct:
   - _____Muscle weakness
   - _____Contractures
   - _____Faulty posture
   - _____Limp

| Signature of physical therapist | Date |
|---|---|
| | |

# CHAPTER 3

# MUSCLE AND POSTURAL EXAMINATION

## Section I. GENERAL

### 10. Body Mechanics Examination Chart

This chart is used to record findings in preprosthetic and postprosthetic tests of muscle strength and contractures, and postprosthetic test of posture. It is largely self-explanatory (table I), but detailed directions are given in paragraphs 11 through 19 and in paragraphs 50 and 51 in order to explain the standardization of some of the tests, as well as methods of recording test results.

## Section II. FLEXIBILITY AND CONTRACTURE TESTS

### 11. Forward Flexibility Test

This is a means of checking forward mobility of the lower back. In the test position, the patient sits on a plinth with legs extended forward and tries to reach his toes. (See fig. 13.) Extent of limitation is recorded as the number of inches by which he fails to touch his toes. If the patient shows much limitation, this test should be followed by the straight-leg raising test to determine whether any hamstring tightness exists. (See fig. 14.)

*Figure 13. Normal forward flexibility test. The patient is able to touch fingertips to toes with knees straight and with well-rounded contour of entire spine.*

*Figure 14. Straight-leg raising test for hamstring tightness. This patient shows marked restriction due to tightness in hamstring muscles. Normal length of hamstrings would permit flexion of the hip to about 85° with the leg in full extension, as required in this test.*

*a.* When the patient reaches forward, the contour of his lower back should be noted. The hamstring muscles may be relaxed and allow more than normal hip-joint motion; the upper back may be more than normally flexible or it may be in a definitely kyphotic position so that the patient is able to touch his toes even though his lower back is considerably limited in flexibility.

*b.* Low back flexibility cannot be determined accurately when the test is given with the patient in a standing position. Any rotation of the pelvis (clockwise—forward on the left; or counterclockwise—forward on the right) will necessarily be accompanied by rotation of the lumbar spines. This, in turn, will limit trunk flexion from a standing position.

When the patient is sitting on a plinth with his legs extended forward, the pelvic rotation usually disappears (except in cases of structural rotation); thus, trunk flexion becomes a more accurate index of the limitation of low back flexibility.

## 12. Extensibility Test

This is a means of checking general ability to extend hips and knees, flatten lumbar spine, and raise arms overhead. (See fig. 15.) The patient should be able to lie supine on a plinth with knees and hips extended, lumbar spine flat on the plinth, and arms raised directly overhead. Findings are recorded as N (normal), F (fair), or P (poor).

*Table II. Comparative Muscle Grading*

| Test | Percentages | Letters | Numerals | | | Neurological ratings | Combination ratings | | |
|---|---|---|---|---|---|---|---|---|---|
| Full range of motion against gravity with *normal* resistance, repeated several times without signs of fatigue. | Contracted or hypertrophied. | Normal+ (N+) | | 13 | | | | | |
| | 100 | Normal (N) | 5 | 12 | 0 | ++++ | Normal (N) | 9 | Normal. |
| | 95 | Normal− (N−) | | 11 | | | Normal− (NM) | 8 | Increase against resistance but quite normal. |
| Full range of motion against gravity with *medium* amount of resistance, repeated several times without sign of fatigue, but tires quickly or is unable to complete range of motion with normal resistance. | 90 | Good+ (G+) | | 10 | | | | | |
| | 80 | Good (G) | 4 | 9 | 1 | +++ | | | |
| | 70 | Good− (G−) | | 8 | | | Good+ (GP) | 7 | Beginning power against added resistance. |
| Full range of motion against gravity, minimum resistance. | 60 | Fair+ (F+) | | 7 | | | Good (G) | 6 | Well-defined control over gravity or friction. |
| Full range of motion against gravity, *no* resistance. May tire after 3 to 6 movements. | 50 | Fair (F) | 3 | 6 | 2 | ++ | | | |
| Almost full range of motion against gravity | 40 | Fair− (F−) | | 5 | | | | | |
| Beginning motion against gravity or completion of arc of motion with gravity eliminated, either against friction of table or with minimum resistance. | 30 | Poor+ (P+) | | 4 | | | Good− (GM) | 5 | Beginning action against gravity or friction. |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| No motion against gravity but completes range of motion with gravity eliminated (no friction). | 20 | Poor (P) | 2 | 3 | 3 | + | Fair+ (FP) | 4 | Beginning action of joints but not against gravity or enough to overcome friction of table. |
| Partial range of motion with gravity eliminated. | 10 | Poor− (P−) | | 2 | | | Fair− (FM) | 2 | Definite muscle action without much influence on the joint. |
| Palpable or visible contraction of muscle, but no apparent movement of part. | 5 | Trace (Tr) | 1 | 1 | 4 | ± | Action weak (AW) | 1 | Definite muscle contraction. Between IA and AW is fibrellation or questionable contraction. |
| No contraction felt in muscle | 0 | 0 | 0 | 0 | 5 | 0 | Inactive (IA) | 0 | No appreciable motion. |

*Figure 15. Normal extensibility test. Above patient would be rated normal.*

## 13. Contracture Test

*a.* Limitation of motion due to contractures in gastrocnemius, soleus, hamstrings, hip flexors, and hip abductors is tested and recorded in degrees. In testing limitation of motion due to contractures in the hip flexors, the patient lies on a plinth as illustrated in figure 16. The patient tries to extend his right thigh while holding his pelvis flat on the table; all motion is, therefore, true hip joint motion alone.

*Figure 16. Position of patient for measuring degree of hip flexion contracture. Opposite thigh is flexed on chest to help keep lumbar spine flat on table. The above patient shows a hip flexion contracture of approximately 30°.*

*b.* The normal state of extensibility of the pectoral muscles is illustrated by the position of the arms in figure 15; the amount of tightness

in pectoral muscles should be recorded as sl. (slight), mod. (moderate), or mark. (marked).

## Section III. MUSCLE STRENGTH TESTS

### 14. Comparative Muscle-Grading Table

Muscle strength tests of the lower extremity and abdominal muscles are to be recorded in percentages accorded to table II. Detailed instructions for testing particular muscles are given in paragraphs 15 and 16.

### 15. Gluteus Medius Muscle, Posterior Portion

In this test the patient lies on his side with his trunk and pelvis in straight alignment. (See fig. 17.) His upper leg is placed in position with leg extended and thigh in abduction, slight extension, and slight external rotation. The patient holds against resistance which is applied to his ankle in a downward and slightly forward direction.

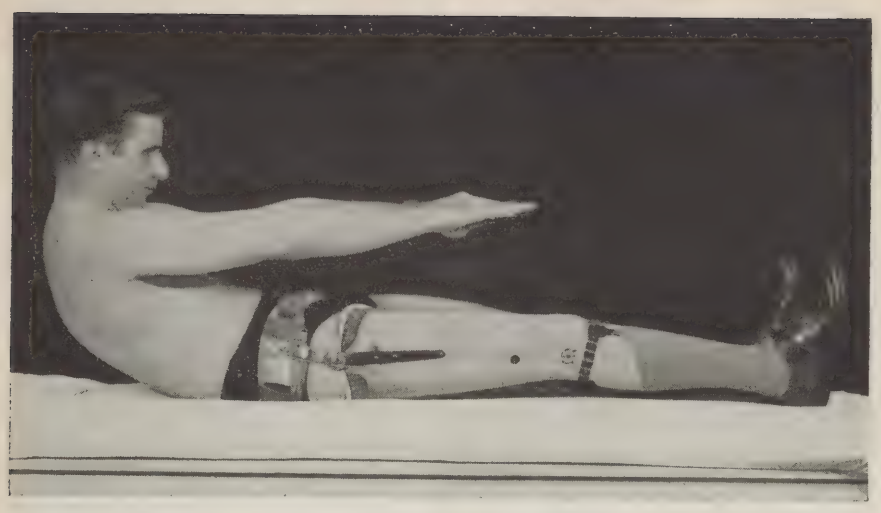
*Figure 17. Testing strength of posterior portion of gluteus medius.*

### 16. "Upper" and "Lower" Anterior Abdominal Muscles

These muscles are tested and graded as follows:

| Percentage | Test |
|---|---|
| 100 | (1) With hands clasped behind head, roll pelvis backward and "fold" to sitting position. Legs are not supported until trunk flexion is complete, but may be supported as soon as the pelvis should normally begin flexing on the thighs. (See fig. 18① and ②.)<br>(2) With hands clasped behind head, roll pelvis backward and hold lumbar spine flat on table as legs are raised and lowered. (Leg raising tests are modified for unilateral amputees with prosthesis by resting prosthesis on normal leg.) (See fig. 19.) |

| Percentage | Test |
|---|---|
| 80 | (1) With arms folded on chest, roll pelvis backward and "fold" to sitting position.<br>(2) With hands clasped behind head, roll pelvis backward to flatten lumbar spine. Your legs are then raised at a 40° angle to the table by the examiner; try to keep back flat on table and at same time retain legs in raised position. |
| 60 | (1) With arms down at side (but with no assistance from hands or elbows), roll pelvis and "fold" to sitting position.<br>(2) With hands clasped behind head, roll pelvis backward to flatten lumbar spine. Your legs are then raised at a 60° angle to the table by the examiner; try to keep back flat on table and at same time retain legs in raised position. |
| 50 | (1) With arms down at side, roll pelvis and lift head and shoulders about 4 or 5 inches from the table.<br>(2) With hands clasped behind head, roll pelvis backward to flatten lumbar spine. Your legs are then raised at a 75° angle to the table by the examiner; try to keep back flat on table and at same time retain legs in raised position. |



① *Legs are not supported during movement of flexion of thorax on pelvis.*

② *As trunk-raising continues by flexion of pelvis on thigh, legs are held down on table by examiner.*

*Figure 18. Testing strength of "upper" anterior abdominal muscles. Above figures show position of arms for 100% (normal) trunk-raising test. See paragraph 16 for positions in 80 percent and 60 percent trunk-raising tests.*

*Figure 19. Testing strength of "lower" anterior abdominal muscles. Strong action of anterior abdominal muscles keeps lumbar region flat on table as weight of legs is raised and lowered. Test may be modified for unilateral amputees who have been fitted with prostheses, as above, by placing prosthesis on normal leg to keep knee of prosthesis extended. Above patient shows 100 percent (normal) strength for these muscles.*

## Section IV. POSTURE TESTS

### 17. Plumb-Line Tests

There is one standard reference point in all postures, the base, where the feet touch the floor. To determine variations in posture, a plumb line is suspended from a stationary point above the patient's head to the fixed reference point at his feet.

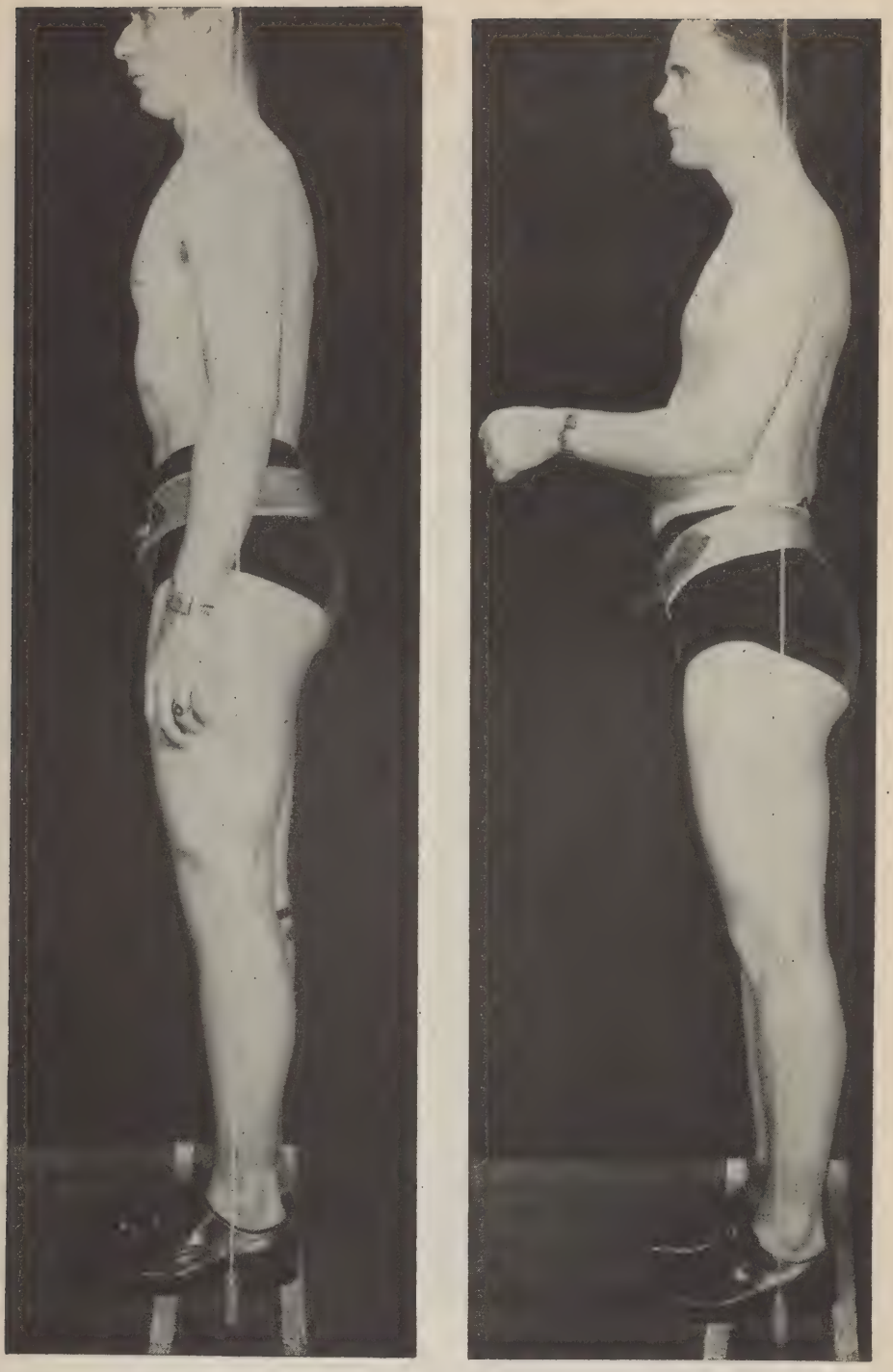
When a patient has correctly balanced posture, his body will coincide with the plumb line at several points above the normal base; when he has faulty posture, there will be a lack of normal alignment. In the test for anteroposterior alignment, the plumb line will coincide with the frontal plane of the body in normal posture; in the test for lateral alignment, it will coincide with the sagittal plane.

### 18. Plumb-Line Test for Anteroposterior Alignment

To assume the test position, the patient steps up to the plumb line and places his feet so that the plumb-bob hangs in line with a point just anterior to his lateral malleolus. (See fig. 20.)

If his posture is correctly balanced, the patient's body will coincide with the plumb line at the following points above the normal base:

*a.* Posterior to the patella.
*b.* Through the hip joint (anterior to the greater trochanter).
*c.* Midway between abdomen and back.
*d.* Through the shoulder joint.
*e.* Through the lobe of the ear.



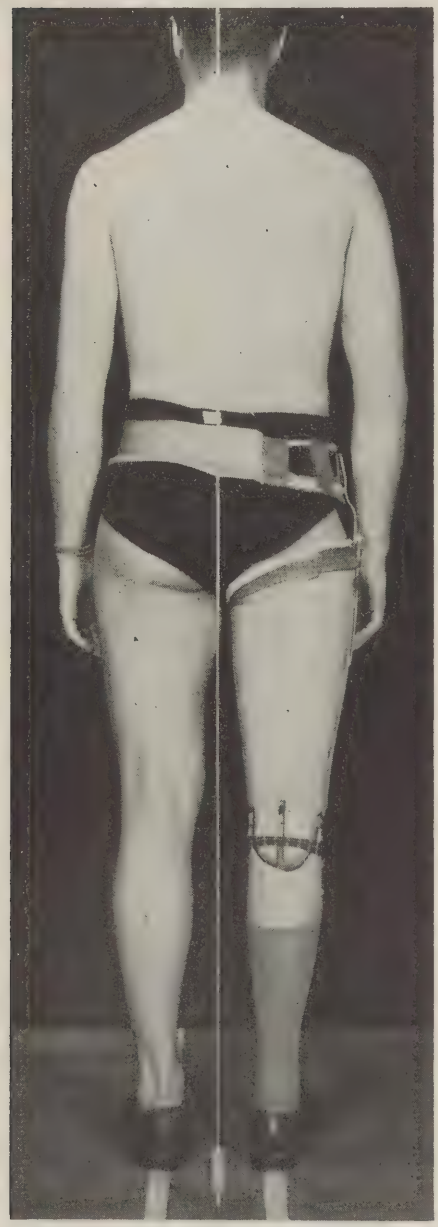
① *Above patient shows good postural alignment except that his head and shoulders are slightly forward.*

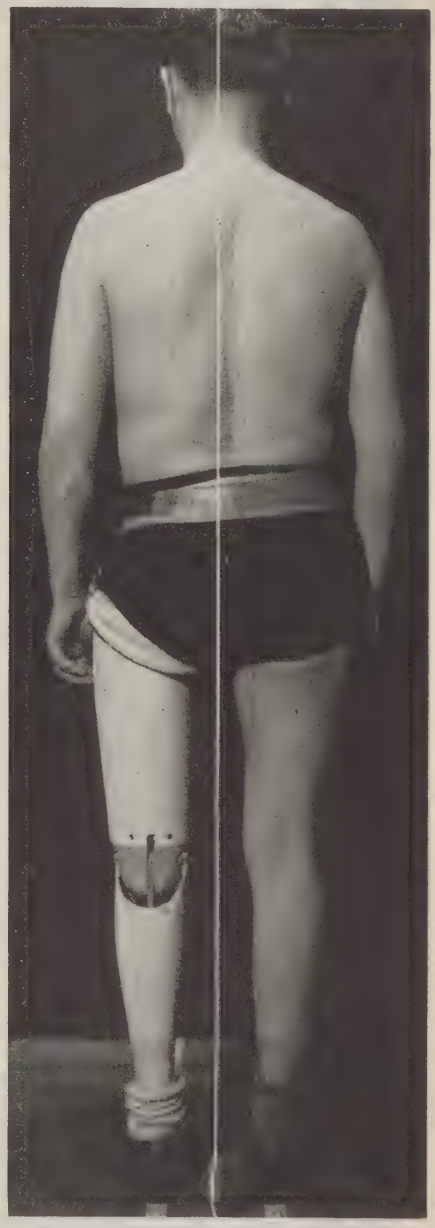
② *Above patient shows faulty postural alignment with pelvis slightly displaced marked lordosis and head forward. (Note clockwise rotation of pelvis and trunk; compare with figure 21②.)*

*Figure 20. Plumb line test for anteroposterior alignment.*

## 19. Plumb-Line Test for Lateral Alignment

To assume the test position, the patient stands with the inner border of his heels 3 inches apart and equidistant from a line which coincides with





① *Above patient shows good (but not perfect) postural alignment, and good weight distribution over both legs.*

② *Above patient shows faulty postural alignment. Displacement of pelvis, trunk, and head toward right shows that more weight is being borne on the normal leg than on the prosthesis.*

*Figure 21. Plumb line test for lateral alignment.*

the tip of the plumb-bob. (See fig. 21.) (Bilateral amputees should stand with heels as nearly 3 inches apart as possible.) Weight should be distributed evenly on both feet.

If his posture is correctly balanced, the midline of the patient's body will coincide with the plumb line.

# CHAPTER 4

# PREPROSTHETIC EXERCISE PROGRAM

## Section I. GENERAL

### 20. Purpose of Exercises

The purpose of this program is to correct defects in body alignment and to establish muscle balance and normal range of motion before fitting with prosthesis. This will insure that the body and prosthesis function together with maximum efficiency.

*a.* Before the patient is ready for the postprosthetic program of walking, stair-climbing, turns, etc., he must accomplish the following objectives of the preprosthetic program:

*Figure 22. Anterior pelvic tilt due to hip flexion contracture.*

(1) Increasing muscle strength of extremity involved, including correction of existing contractures when condition of patient permits.

(2) Correcting defects in muscle balance and body alignment.

(3) In cases of unilateral amputation, improving weight-bearing strength and balance of normal leg.

(4) Maintaining general muscle tone.

*b.* When an amputee is measured for his prosthesis before correction of defects in body mechanics, the limb-fitter will necessarily fit the prosthesis to the deformity. As a result, the patient tends to be held in the position of deformity despite subsequent efforts to correct his postural defects. For example, if an abduction contracture exists in the thigh stump at the time of the fitting, the patient will stand in a position of lateral pelvic tilt; if a hip flexion contracture of the stump is present, the patient will stand in a position of anterior pelvic tilt (lordosis), and his prosthesis will fit and tend to hold him in this position. (See fig. 22.)

If defects are corrected by exercise before measuring and fitting takes place, the need for constant alterations in the fit of the prosthesis will be obviated.

## 21. Selection of Exercises

The preprosthetic exercise program may be divided into two stages: the preoperative (before final surgical revision), and the postoperative (after final surgical revision). This division into stages does not necessarily influence the over-all selection of exercises, since the need for a particular exercise continues until the defect of the given muscle group is corrected. Some exercises may have to be discontinued temporarily during the early postoperative stage, but their essentiality will undoubtedly be increased by the interruption.

The stages through which a patient progresses, however, will influence the administration of the exercise program in several ways:

*a.* Preoperative Stage. Exercises of involved part are not usually given during the healing phase following the initial guillotine amputation. As soon as the stump is healed, exercises may be given upon the approval of the ward officer. However, since the surgical revision is usually accomplished shortly after the stump has healed, this period is not very long.

*b.* Early Postoperative Stage. The intensity of some exercises given in the preoperative stage may have to be decreased from an active or resistive movement to a movement of static contraction; other exercises may have to be omitted temporarily.

*c.* Preoperative and Postoperative Ambulatory Phases. Normal leg balance exercises in standing can be added.

## 22. Strengthening Weak Muscles

*a.* After the initial postoperative period, hip extension, hip adduction, and quadriceps exercises (for B/K's) are usually best performed with pulley weights. Care must be taken to insure pelvic fixation in the first two of these exercises. Exercises for the remaining muscles of the involved extremity are usually best performed against resistance provided by another person.

The governing principle in all of these exercises is to increase resistance progressively as muscle strength improves.

*b.* Occasionally, tests reveal weakness of the muscles involved in contracture. The contracture may be due to changes in joint capsules, ligaments, or soft tissues. Therefore, it is advisable to reduce the deformity before instituting exercises to strengthen these muscles.

## 23. Stretching Existing Contractures

*a.* Hip Flexion. The choice of the exercise position may depend upon the condition of the patient, available apparatus, or other factors.

*Figure 23. Stretching contracted hip flexors with patient in supine position. Note that the normal thigh is in a comfortably flexed position, the lumbar region is flattened, and the pelvis is fixed firmly by the strap. The stretching of the contracted hip flexors is a passive procedure accomplished by the physical therapist's steady pressure on the anterior iliac crest and the distal half of the thigh stump. (In practice, the physical therapist stands on the side of the amputation.) The patient assumes the above position only when he cannot assume the preferred position in figure 25.*

Regardless of what position is employed, however, the technique must include firm fixation of the pelvis to prevent anterior pelvic tilt while pressure is being exerted to stretch the hip flexors.

(1) The *standing position* is not recommended because of the difficulties encountered in fixing the pelvis. (See par. 11*b*.)

(2) In the *supine position* (with or without the extension table), a strap is used in addition to the force exerted by flexion of the normal thigh in order to fix the pelvis. When the pelvis is fixed by a strap, the normal extremity need not remain in such extreme flexion while the hip flexors of the opposite thigh are being stretched; it can rest on the table in knee-bent position. (See figs. 23 and 26.)

(3) See figure 24 for the *prone position.*

*Figure 24. Stretching contracted hip flexors with the patient prone and with his legs over the end of the plinth. Note that the patient leans as far forward as possible with comfort. He grasps the sides of the plinth for support. The physical therapist maintains stabilization of the thigh of the patient's normal extremity by counter pressure of her left knee. This stretching is a passive procedure accomplished by the physical therapist's applying traction on the distal half of the stump and, simultaneously, pressure over the gluteal region. The above position is ordinarily employed only when the position shown in figure 25 cannot be used.*

(4) See figure 25 for the *sitting position.*

*b.* Hip Abduction. (1) *Side-lying position.* The extension table may be used as in hip-flexor stretching. (See fig. 26.) The patient lies on the side of his normal leg with his knee and thigh flexed about 45° to

60°. The pelvis is fixed to the table by a strap. The weight pulls downward to stretch the stump abductors.

*Figure 25. Stretching contracted hip flexors and hip abductors in the sitting position. Note that the patient is sitting flat against the railing of the frame with his normal leg extended as fully as possible. The strap fixes his pelvis still further; and the weights (not shown) are exerting traction in the direction in which his thigh is extended. The patient is making no active effort at movement of the right hip joint. The use of the radiant heat infra-red lamp, as illustrated, facilitates relaxation of muscle spasm. Since the single application of traction, as above, usually pulls the thigh in abduction as well as extension, the abduction component is negated by secondary traction. This, in turn, pulls the thigh in adduction-extension. This appears to be the most satisfactory arrangement for simultaneously stretching contracted hip flexors and contracted hip abductors.*

(2) *Supine position, or prone position with pillow under abdomen.* Fixation of the pelvis is essential in order to localize stretching to the stump abductor muscles. Without pelvic fixation, the pelvis tends to ride upward on the side of the normal leg. A wide belt should be fastened around the pelvis and attached to the table by a strap which will pull the pelvis down on the side of the normal leg.

(3) *Standing position.* This position is not recommended unless the patient can stand with his pelvis fixed by a pelyic-grip apparatus.

(4) *Sitting position.* See figure 25.

*c.* Using Weights to Stretch Hip Flexors or Abductors. It must be strongly emphasized that a weight must be kept on long enough and be heavy enough to overcome the ability of the muscle to pull against

it. Otherwise, the weight will act like a resistance stimulus and will *increase the strength* of the muscle instead of *stretching* it.

(1) *The amount of time* will usually be a 15- to 30-minute period.

(2) *The amount of weight* will vary with the individual patient—the length of his stump, the degree of contracture, and his tolerance. The maximum amount of weight should be used immediately (without gradual increase); it should be sufficient to produce a definite feeling of relaxation in the muscle within several minutes. Immediately after this exercise, the patient usually complains of temporary pain in the "hip joint" (actually the hip flexors) and of difficulty in flexing his thigh. He should be told to expect such reaction and reassured that the symptoms are not serious.

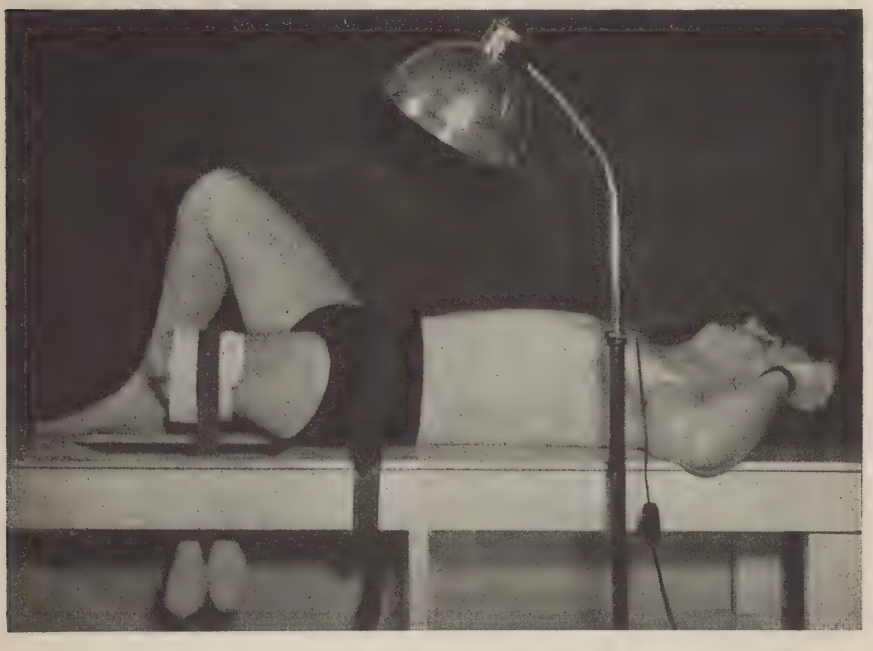


*Figure 26. Use of the extension table in stretching contracted hip flexors.*

## Section III. POSTURE EXERCISES

### 24. Typical Posture Faults

Individual examination of patients will determine individual variations in exercise. However, since postural defects tend to assume the same pattern in most patients, it is possible to establish a general corrective exercise program which will apply in most cases.

The following chart outlines conditions of muscle imbalance which usually accompany (as a cause of, or result of) typical faults in *adult* posture. It also prescribes exercises to correct muscle imbalance and posture defects:

| Posture fault | Muscle weakness | Muscle tightness | Exercises and other corrective procedures for muscle imbalance |
|---|---|---|---|
| *a.* LORDOSIS. | "Lower" anterior abdominals.<br>(External oblique and rectus abdominis.)<br><br>Hamstring muscles and gluteus maximus, less frequently than abdominal muscles. | Low back erector spinae.<br><br>Ilio psoas.<br><br>Other hip flexors. | *Strengthening "lower" anterior abdominal muscles:*<br><br>Supine position:<br>(1) Roll pelvis until back is flat on table by pulling up and in with lower abdominal muscles. Hold low back flat on table and breathe in and out to relax upper abdominal muscles.<br>(2) With hands up beside the head, knee bent, and foot flat on table, roll pelvis until back is flat on table by pulling up and in with the lower abdominal muscles. Hold back flat on table and straighten leg by sliding heel down along table. Keep pelvis rolled and return knee to bent position. Stump remains extended on table. (See fig. 27.)<br>*Stretching tight low back muscles:*<br>Sitting position:<br>With knees slightly bent and arms extended forward, pull up and in with lower abdominal muscles to roll the pelvis back. Then bend upper trunk forward to round lower back, and reach toward toes.<br>*Strengthening abdominal muscles and stretching low back muscles* (combined exercise):<br>Supine position:<br>With arms at sides, palms up, and knees flexed on chest, lift hips a few inches from table to flex pelvis on thorax (but not to point of dorsal flexion). |

| | | | |
|---|---|---|---|
| | | | *Stretching hip flexors* (see par. 23):<br>Supine position:<br>Keep low back flat on table by flexing normal leg (Knee to chest) with aid of hands around thigh. As assistant presses stump down toward table, help with active hip extension. (See fig. 23.)<br>Prone position:<br>With legs over end of table and trunk resting on table, fix pelvis by pressure against normal leg. At the same time, extend hip joint on stump side to stretch hip flexors. (See fig. 24.)<br>Sitting position:<br>See figure 25.<br>Supine position (with extension table):<br>See figure 26. |
| *b.* KYPHOSIS. | Dorsal erector spinae.<br><br>Middle and lower trapezius. | Pectorals and "upper" anterior abdominal muscles (internal oblique and rectus abdominis). | *Strengthening dorsal erector spinae and middle and lower trapezius:*<br>Sitting position:<br>On stool with lower back against wall (or on floor with legs extended forward, and with back to wall), hands up beside head—keeping low back against wall, straighten upper back, trying to touch entire back to wall. Then press elbows and head back toward wall, keeping chin down and in. (See fig. 28.)<br>*Stretching tight pectorals:*<br>Sitting position:<br>Starting with arms in an abducted and externally rotated position, move arms backward and slightly upward. Physical therapist aids arm movement and stabilizes upper back by pressure of her knee. (See fig. 29.) |

| Posture fault | Muscle weakness | Muscle tightness | Exercises and other corrective procedures for muscle imbalance |
|---|---|---|---|
| *c.* FORWARD HEAD. (This position is usually compensatory for a depressed chest; its correction will greatly depend on correction of faulty chest and upper back positions.) | Anterior neck flexors (anterior-vertebral cervical spine flexors). | Cervical spine extensors, including upper trapezius.<br><br>Sternocleidomastoid. | *Strengthening and stretching* (combined exercise):<br>Supine position:<br>Knee is bent and foot is flat on table, arms are in "inverse T" position, \|___\| (arms elevated to shoulder level, hands up beside head). Raise chest (without arching back) and depress chin in direction of flattening cervical spine. (This exercise is somewhat comparable to flattening of lumbar spine in cases of lumbar lordosis, except that patient is not expected to touch entire cervical spine to table.)<br>Sitting position:<br>On stool with lower back against wall (or on floor with legs extended forward and with back to wall), hands up beside head—keeping low back against wall, straighten upper back, trying to touch entire back to wall. Then press elbows and head back toward wall, keeping chin down and in. (See fig. 28.) |
| *d.* PRONATED FOOT. | Tibialis posterior and long toe flexors. | Peroneals | *In preweight bearing stage—foot exercises for tibialis posterior and for toe flexors:*<br>Supine positions:<br>With toes gripped, turn foot in a position of inversion in plantar flexion.<br>*In weight-bearing stage:*<br>Postural strain on weak tibialis posterior and toe flexor should be relieved by placing an inner border wedge on the heel, or a Thomas heel on the shoe (of normal leg in case of unilateral amputees), if the ward officer so recommends. |

| | | | |
|---|---|---|---|
| *e.* INTERNALLY ROTATED FEMUR. | Hip external rotators, particularly posterior portion gluteus medius. | Tensor fascia femoris---- | *In preweight-bearing stage—exercises for external rotators* (if examination shows them to be weak):<br>Supine position:<br>With lower extremities in normal alignment, perform an outward axial turn.<br>Side-lying position (fig. 17):<br>As in test for strength of posterior portion of gluteus medius (par. 15), keep trunk and pelvis in straight alignment. Place upper leg in position with leg extended and thigh in abduction, slight extension, and slight external rotation. Hold against resistance which physical therapist applies to ankle in a downward and slightly forward direction.<br>*In weight-bearing stage:*<br>Strain on external rotators should be relieved by placing an inner border wedge on heel, or Thomas heel on shoe (of normal leg in case of unilateral amputees), as for pronation, if the ward officer so recommends.<br>With the knee in extension, the hip joint and astragalonavicular joint act together as a universal joint; the pronation of the foot results in internal rotation of the femur, and vice versa. |

*Figure 27. Exercise to strengthen "lower" anterior abdominal muscles.*

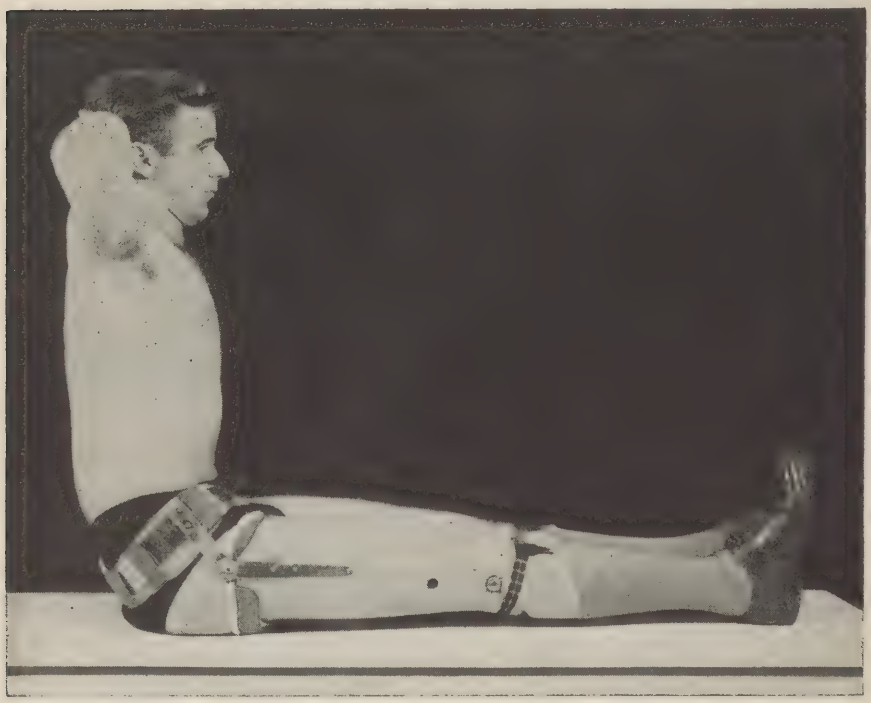


*Figure 28. Exercise to correct faulty positions of upper back and head. (Directions in paragraph 24b must be followed exactly.)*

*Figure 29. Position for stretching contracted pectoral muscles.*

## Section IV. EXERCISES FOR UNILATERAL AMPUTEES

### 25. Purpose

This section prescribes exercises for strengthening and improving balance on the normal leg.

The number of repetitions or amount of resistance offered a patient in particular exercises increases in direct proportion to the return of muscle strength.

### 26. Bed Stage

| Exercises | Purpose | Position and movements |
|---|---|---|
| *a.* FOOT EXERCISES. | | |
| Dorsiflexion | Maintaining tone and strength of dorsiflexors and offsetting tendency toward gastrocnemius soleus contracture. | Supine position:<br>Pull foot upward (toward body). |
| Inversion<br>(Exercise is done in both dorsiflexion and plantar flexion, where latter is not contraindicated by a contracture in that position.) | Maintaining tone and strength of tibialis anterior and tibialis posterior muscles. | Supine position:<br>Pull foot upward and slightly inward.<br>Push foot downward and slightly inward. |

| Exercises | Purpose | Position and movements |
|---|---|---|
| Toe flexion | Strengthening both long and short flexors of toes, and preventing contracture of toe extensors. | Supine position:<br>Grip toes, strongly flexing all toe joints. |
| Foot circling<br>(Not to be performed where contraindication in the form of contractures of gastrocnemius, soleus, peroneals, or or other muscles exists.) | Maintaining general strength of leg and foot muscles. | Supine position:<br>Beginning with foot turned inward, describe a complete circle.<br>With toes gripped, describe a complete circle, beginning with foot turned inward. |
| *b.* Knee Exercises. | | |
| Quadriceps "setting" | Preventing atrophy and maintaining tone and strength of quadriceps muscle group. | Supine position:<br>Contract quadriceps muscle without moving knee joint, by tensing muscle and exerting upward pull on patella. |
| Knee extension | Preventing atrophy and maintaining tone and strength of quadriceps muscle group. | Supine position (pillow under knee):<br>Raise lower leg to straighten knee.<br>Emphasize *complete* extension of leg. |
| *c.* Hip Exercises. | | |
| Hip extension | Preventing atrophy and maintaining tone and strength of hip extensors. | Prone position:<br>Keeping knee straight, extend hip fully. (Back must not arch during movement.) |
| Hip abduction | Preventing atrophy and maintaining tone and strength of hip abductors, with particular attention given to gluteus medius muscle. | Side-lying on stump side:<br>Place leg with knee straight in abduction, slight extension, and outward rotation; hold against resistance. (Same movement as test for gluteus medius, posterior portion.) (See fig. 17.) |

| Exercises | Purpose | Position and movements |
|---|---|---|
| *d.* COMBINED EXERCISE. | Strengthening muscle groups particularly subject to weakness because of position and lack of use in bed. | Supine position, with hands up beside head, elbows resting on bed, and knee slightly flexed over pillow: Components of following exercise are performed simultaneously:<br>(1) Pull foot upward and slightly inward.<br>(2) Press knee and hip downward.<br>(3) Pull up and in with lower abdominal muscles, flattening lower back. |

## 27. Ambulatory Stage

| Exercises | Purpose | Position and movements |
|---|---|---|
| *a.* BALANCING ON NORMAL LEG. | Developing coordination of standing balance. | Standing on normal leg, near bed footrail or other support:<br>(1) Stand with hand lightly on support and maintain good postural alignment. (Use minimum support.)<br>(2) Stand unsupported. (Progression may be marked by length of time (number of counts) for which position can be held.) |
| *b.* HOPPING ON NORMAL LEG. | Developing coordination of standing balance. | Standing on normal leg near object of support:<br>Hop lightly on foot. (Shock of impact should be absorbed in foot, ankle, knee, and thigh.) |
| *c.* DEEP KNEE BENDING. | Developing coordination of standing balance. | Standing position (fig. 30):<br>Perform deep knee bend, raising arms forward. |

*Figure 30. Deep knee bending exercise to strengthen normal leg. (Note value of exercise in sitting and rising from a chair.)*

## Section V. GENERAL EXERCISES

### 28. Purpose

This section describes exercises for muscles which have not previously received specific attention in this manual.

### 29. Exercise for Oblique Abdominal Muscles

Supine position:

Raise trunk to half-sitting position, twisting to right and reaching with left hand toward right thigh, keeping legs flat on plinth.

Repeat exercise on opposite side.

### 30. Exercise for Lateral Abdominal Muscles

*a.* Lateral Hip "Hiking."

Supine position:

"Hike" hip up on right side (draw hip toward shoulder).

*b.* Lateral Trunk Raising. *This exercise should not be given to lateral abdominals on involved side where there is an abduction contracture of the thigh.*

Lying on right side with legs supported by operator:

With body in straight alignment, raise trunk sideways up from plinth.

(See fig. 31.)

Repeat exercise on opposite side.

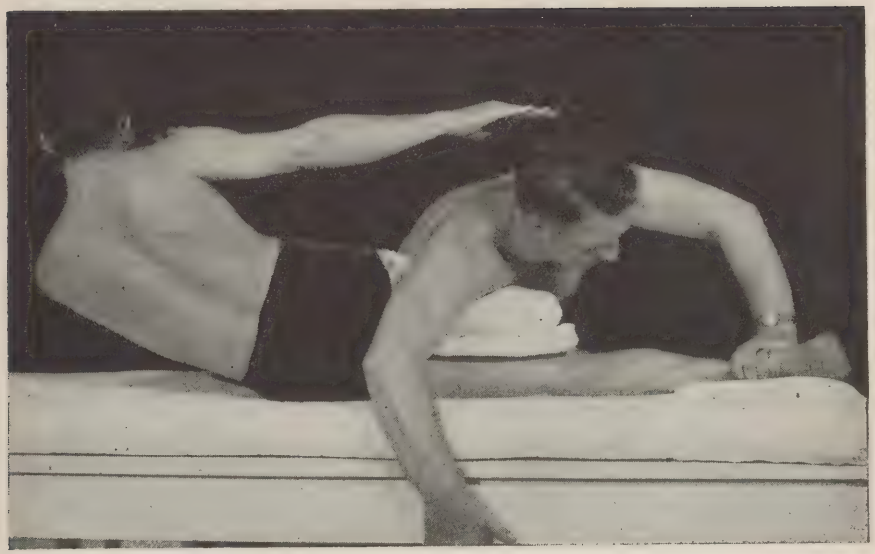


*Figure 31. Exercise to strengthen lateral abdominal muscles.*

## 31. Exercise for Upper Anterior Abdominal Muscles

Supine position:

Roll pelvis to flatten lower back on plinth. With arms extended, raise head and shoulders from plinth. Do not attempt to come to a sitting position, but raise upper trunk as high as back will bend—about 8 inches. (See fig. 32.)

*Figure 32. Head and shoulder exercise to strengthen upper anterior abdominal muscles.*

## 32. Exercise for Lower Back Muscles

Prone position, with legs supported by operator:

With hands clasped behind back, raise trunk upward, arching back; draw shoulders back, keeping arms free from body.

## 33. Breathing Exercise

Supine position:

Breathe fully and deeply in through nose and out through mouth. (Aim for intercostal expansion and diaphragmatic contraction. Guard against raising the shoulders and mere elevation of the chest by arching the back.)

## 34. Exercises Contraindicated

Exercises for sternocleidomastoid, pectoral, and hip flexor muscles have been omitted in this section because ordinary supine bed positions and movements of the head, arms, and legs in the forward plane of the body provide sufficient use to maintain their tone. Frequently, these muscles are over-used and even necessitate corrective measures such as stretching and lengthening.

# CHAPTER 5

# INDIVIDUAL WALKING INSTRUCTION

## Section I. GENERAL

### 35. Administration

The general procedures in establishing and managing the instruction program are set forth in paragraph 4; a more detailed discussion of classification, apparatus, and teaching technique is set forth below.

### 36. Apparatus

A well-equipped room for conducting walking and exercise classes should include:

*a.* Parallel Bars (standard item PO10230, bars, parallel; two sections)—about 20 feet long, 3 feet high, and 2 feet 2 inches apart, with lines 1½ inches wide and 5 inches apart painted on the floor between bars (measurement taken from inner borders of lines).

*b.* Mirror (standard item P504550, mirror, postural training: triple, full length)—6 feet high and 10 feet wide, composed of portable posture mirrors.

*c.* Lines on Floor at Right Angles to Mirror—20 feet long, 1½ inches wide, and 5 inches apart (measurement taken from inner borders of lines).

*d.* Stairs—each step 11 inches wide; six low steps 5 inches high on one side; four high steps 7½ inches high on other side. Rails on both sides of steps, about 2 feet 8 inches high.

*e.* Walking Ramp—about 10 feet long, 1 foot 9 inches wide; height is 1 inch at low end and graded to 18 inches at the upper end. Rails on each side of ramp, 36 inches high. Three 6-inch steps leading from upper end of ramp to floor.

*f.* Phonograph and Slow Fox-Trot and March Records.

*g.* 16-mm Projector, Screen, Viewer, and Editing Equipment.

### 37. Teaching Technique

It is imperative for amputees to appreciate the goal of walking classes and the necessity for adhering to their established sequence. Patients must be made to realize that merely learning to get around on a prosthesis is not enough—a patient does not achieve maximum utility from his prosthesis until he has learned to walk as normally as possible.

Three components of excellent walking with a prosthesis are balance and muscular coordination in motion, smoothness of walking rhythm, and steps of equal length. These components should be taught to the patient as follows:

*a.* Maintaining Walking Balance. Balance is achieved by equal distribution of weight above a center of support. Therefore, in order to obtain walking balance an amputee must walk with his feet under the weight-bearing axis of his body in such a way that he attains equal weight distribution during his walking stride. Helpful exercises are considered in paragraphs 39, 40, and 47.

*b.* Keeping Soles and Heels Close to Ground During Walking. In order to duplicate the normal stride with the prosthesis, as nearly as possible, it is imperative to adjust the travel pattern of the prosthetic foot so that it will duplicate that of the normal foot. Time and travel distance with the prosthetic foot must be synchronized with that of the normal foot. Before a patient can do this, he must understand the mechanics of both the normal and the prosthetic legs.

*Table III.*

**PHYSICAL THERAPY ACHIEVEMENT TEST FOR LOWER-EXTREMITY AMPUTEES**

| Name | | | Ward number |
|---|---|---|---|
| Type of amputation | Date of final surgical revision | | Handedness |
| Date walking began | | Date walking completed | |
| Gradings (Check one) | Poor☐ | Fair☐ | Good☐ Excellent☐ |

| *Achievement* | *Beginners* | *Intermediate* | *Advanced* |
|---|---|---|---|
| General posture | | | |
| Balance | | | |
| Forward walking | | | |
| Stair climbing | | | |
| Ramp walking | | | |
| Turns: 180° | | | |
| 90° | | | |
| 45° | | | |
| Walking on straight line | | | |
| Prosthetic foot close to floor | | | |
| Equal length steps | | | |
| Walking rhythm | | | |
| Backward walking | | | |
| Sideward walking | | | |
| Sitting on chair | | | |
| Rising from chair | | | |
| Sitting on floor | | | |
| Rising from floor | | | |
| Picking up objects | | | |
| Balance on prosthesis | | | |
| Curb, stepping on and off | | | |
| Walking on rough terrain | | | |
| Walking on grass, sand, etc. | | | |
| Hill climbing | | | |

| Signature of physical therapist | Date |
|---|---|

In the normal gait, the sole and heel are carried as close to the ground as possible from the point at which the foot leaves the floor to the point at which it returns in forward position. With this kind of movement, the foot covers the shortest distance between these two points in the least amount of time, and with the least possible effort.

The normal knee is slightly flexed when the leg is in its forward walking position, whereas the prosthetic knee is completely extended in that position. Because of this variance in mechanics, the length of stride with the prosthesis tends to be slightly longer than the stride with the normal leg. This tendency can and must be minimized to avoid the typical "amputee gait."

Exercises developing the proper kinesthetic sense for *carrying the sol and heel of the prosthetic foot as close to the floor as possible* are considered in paragraphs 39 through 41.

*c.* Achieving Uniform Stride. Among the common causes of longer stride with the prosthesis than with the normal leg are: (1) prosthesis longer than normal leg, (2) hyperextension of knee joint, (3) swinging prosthesis in abduction, (4) excessive hip flexion, and (5) elevation of pelvis on side of prosthesis. (The last two result when the prosthetic foot is carried too high above the floor.)

Keeping in mind that the prosthetic leg and the normal leg differ in length of stride because of variance of mechanics, it is very important to check the above-knee prosthesis for hyperextension at the knee joint; each 5° of hyperextension will increase the length of stride by about 1¾ inches.

Exercises to promote uniform stride are set forth in paragraphs 40 and 48.

## 38. Classification

Within each of the four groups described in paragraph 4 (unilateral A/K, unilateral B/K, tilting-table, and bilateral amputees), there are three distinct classes (or grades) in walking instruction through which patients progress according to their walking ability: Beginners, Intermediate, and Advanced. (As many of each of these classes are conducted as are necessary for individual instruction, each class period lasting 30 minutes.)

With the exception of bilaterals, all amputees remain in the beginners class until they are able to walk comfortably at a normal walking speed without such aids as crutches or canes. Thereafter, as soon as they can accomplish all the activities prescribed for a class, they progress to the succeeding class.

The Physical Therapy Achievement Test for Lower Extremity Amputees (table III) will be used to record progress in walking and related activities. This record should represent *average* performance throughout the walking program.

Paragraphs 39 through 41 include exercises for unilateral amputees. In general, these exercises apply to A/K, B/K, and tilting-table cases; however, certain modifications are necessary for the last group. For example, patients with disarticulation of the hip joint and loss of contiguous muscles obviously cannot have the same degree of balance and control over the prosthesis as persons without such defects. These patients should not be required to perform the check balance exercises. Special instructions or modifications of a particular exercise for one of the three groups are called to the attention of the instructor.

Paragraphs 42 through 45 describe problems of sitting and walking which are peculiar to tilting-table amputees because of the mechanics of the prosthesis.

Paragraphs 46 through 49 include exercises for bilateral amputees. In general, these exercises apply to A/K, B/K, and tilting-table cases. Where modifications or special instructions are necessary for a particular group, they are called to the attention of the instructor.

## Section II. UNILATERAL AMPUTEES

### 39. Beginners Class

*a.* Objectives. In the beginning phase of walking instruction, emphasis is placed on acquiring *balance* and a normal walking *speed* of about 120 steps a minute. For example, the instructor requests the amputee to walk with his heels between lines 5 inches apart, but does not attempt to influence the patient's walking stride by insisting that he synchronize the time of both feet. Such insistence upon form in the early stage will only hinder the patient's progress.

The ability to judge the position of the prosthetic foot with respect to the floor is a prerequisite to correction of walking technique. A/K amputees must learn to swing the lower portion of the prosthesis at a speed which will produce sufficient momentum to develop this kinesthetic sense of position in the stump. (The amputee must have this ability before he is ready for Intermediate Class exercises which require him to scrape the foot of his prosthesis on the floor or to carry it as close to the floor as possible.) A certain amount of momentum is also necessary before the amputee can move his prosthetic foot without lifting the pelvis on the side of the prosthesis. Therefore, speed and balance, rather than form, are the objectives in the Beginners Class.

*b.* Exercises. (1) *Pelvic Tilt.* Roll pelvis by action of abdominal muscles pulling the pubic symphysis toward the sternum.

*Note.* Instructor checks patient for good body mechanics in upright position, placing special emphasis on lateral and anteroposterior alignment.

(2) *Balance Exercise I.* Stand with feet 8 to 10 inches apart, balancing with aid of crutches or canes.

Stand erect and hold crutches or canes off floor.

Balance—first on one leg, then on the other. Hold weight for same length of time on each leg, keeping both feet on the floor at all times.

(3) *Balance Exercise II.* Place prosthesis in forward walking position with weight on normal leg.

Take full step forward with normal leg, placing inner border of normal foot in line with inner border of prosthetic foot.

Take backward step with normal foot, passing it as close to prosthetic foot as possible.

Repeat exercise about 10 times without interruption. (When exercise is properly executed, a feeling of proper walking balance over the prosthetic leg is experienced. No lateral motion of the body should exist during the exercise.)

*Note.* Instructor should emphasize importance of exercise and explain to amputee the necessity of keeping feet together to maintain balance. Amputee should be requested to conduct the following experiment regarding improper walking balance:

Stand in front of mirror with feet spread about 12 inches apart.

Take step directly forward with normal foot.

Take step directly backward.

Repeat exercise, noting development of lateral motion and feeling of being off balance. Compare with feeling in balance exercise II above.

(4) *Forward Walking Exercise.* Walk between parallel bars, or on crutches, with feet not more than 5 inches apart. *Always advance* normal leg first.

In accomplishing a forward step with the prosthesis, be sure to obtain sufficient speed to break the knee so as to clear the foot from the floor. Check the forward swing of the prosthesis by quickly extending the hip in order to extend the knee.

*Note.* Instructor should warn patient that unless there is sufficient speed, the prostethic foot will drag on the floor and the consequent buckling of the knee may cause him to fall. Patient may develop faulty walking habits when he tries to overcome fear of falling by raising pelvis on side of prosthesis, or by abducting the prosthesis to maintain knee in extension.

(5) *180° Turns* (Walking or Standing). Place normal foot forward, shifting body weight to ball of normal foot, and pivot toward prosthesis.

This leaves prosthetic foot in forward position at completion of the turn and normal leg in position to take forward step.

(6) *Stairs* (For A/K, B/K, and tilting-table amputees in beginning phase).

*To ascend:*

Place normal foot on first step.
Shift body weight over normal leg.
Bring prosthetic foot to a position beside normal foot.
Repeat.

*Note.* Tilting-table amputees may be taught to ascend two steps at a time.

*To descend:*

Place a minimum of three-fourths of the prosthetic foot on lower step.
Shift body weight to prosthesis.
Bring normal foot to a position beside the prosthetic foot.
Repeat.

*c.* Late Stage of Beginners Class. One of the required activities is walking the ramp. When walking up or down an inclined plane, the amputee shortens his stride in order to maintain maximum walking balance. The reduction in the length of his stride is proportionate to the angle of the incline. He uses the same technique in breaking the knee as A/K amputees use in descending steps alternately, as required by the Intermediate Class exercise, Steps. (See par. 40*b* (7).)

*d.* Photography. Each amputee's walking form will be recorded on on 100 feet of motion picture film as soon as he can walk without crutches, canes, or other aids.

## 40. Intermediate Class

*a.* Objectives. In this class, the amputees develop uniform stride and rhythm and learn the more common walking procedures.

Each amputee views motion pictures of his walking form along with his instructor. The instructor points out imperfections in form, and clearly explains reasons for the faults and means of correcting them.

Posture is under constant supervision during this period.

*b.* Exercises. (1) *Balance Exercises I and II.* See paragraph 39*b* (2) and (3).

(2) *Balance Exercise III.* Place prosthesis in forward walking position.

Take a full step with normal leg, forward and backward.

Take a full step forward with normal leg.

Take a full step with prosthesis; then step forward with normal foot, stopping in that position.

Rock back on prosthesis.

Return normal foot to its backward position.

Continue with remainder of exercise, as outlined above.

(3) *Corrective Walking I.* Walk between lines 5 inches apart for at least 10 minutes of each class period, until principles of good walking technique described in paragraph 37 are mastered.

(4) *Standing Turns.*

*45° or 90° Turns (right or left).* Stand with feet about 6 inches apart. Without lifting feet from floor, execute turn as follows: Pivot to left by turning on heel of left foot and ball of right foot (pivot to right by turning on heel of right foot and ball of left).

*180° Turns.* Place normal foot forward about 6 to 8 inches. Shift body weight to ball of normal foot, and pivot toward side of prosthesis.

(5) *Walking Turns.*

*45° Turns.* Pivot on either foot.

*90° Turns.* When turning toward prosthesis, always pivot on prosthetic foot; when turning toward normal leg, pivot on either foot.

*180° Turns.* Shift body weight over normal leg when it is in a forward walking position, and pivot toward prosthesis.

(6) *Stooping to Pick up Objects.*

B/K Amputees. Place prosthesis forward, lean forward from waist, and pick up object from floor.

*A/K Amputees:*

Placing feet slightly apart, weight on normal leg; flex both knees and bend from waist; or

Placing prosthesis back, weight on normal leg; flex both knees and bend from waist.

(7) *Steps.*

*B/K Amputees.* Ascend and descend steps as in Beginners Class (par. 39) until discomfort is no longer experienced. Stairs may then be taken alternately, in the normal manner. There should be no difficulty in guiding the placement of the prosthetic foot on alternate steps.

*A/K Amputees:*

To ascend steps, follow procedure outlined in paragraph 39*b* (6), but take two steps at a time instead of one.

To descend steps, place hand on rail. Place *heel* of prosthesis on edge of step and transfer weight to prosthesis. Move normal foot to alternate step, at the same time breaking knee of prosthesis before the normal foot actually touches the step. *Do not try to descend with any portion of the prosthesis other than the heel on the step.*

*Note.* Instructor should explain to the amputee that his prosthetic knee will break automatically as he shifts his weight forward to bring the normal foot to a lower level. (See Training Film "Sky is the Limit.")

(*8*) *Balance Exercise IV.* Start with feet 8 to 10 inches apart. Face parallel bars, grasping rail for support.

Shift body weight over prosthesis.

Remove normal foot from floor.

Hold normal leg and arms in abduction to help maintain balance.

Balance away from rail.

Shift weight to normal leg and balance.

Continue exercise until it is possible to balance on either leg without any assistance.

(9) *Balance Exercise V.* To develop a finer sense of the fundamental principles of walking, practice walking on a straight line as follows:

Place prosthesis on line.

Walk forward, placing normal foot on line in front of prosthesis.

Walk length of line; abduct arms, if necessary, to maintain balance.

(10) *Sitting and Rising from Chair.*

*Sitting:*

Approach chair from front.

Step close to chair with normal foot about 4 inches in front of opposite corner of chair.

Turn 180° toward prosthesis.

With weight on normal foot, bring prosthetic foot back to same level.

Lean slightly forward, place both hands on knees, and lower body into chair.

*Rising:*

Place normal foot near chair and prosthesis slightly forward.

Lean forward, at the same time lifting body weight out of chair with normal leg and placing hands on knees to assist.

Shift weight to prosthesis and step out on normal foot.

(11) *Sitting and Rising from Floor.* (In the following exercise, the body is visualized as in the center of a clock face and facing a position of 12:00 o'clock.)

*Sitting* (Directions below are for left prosthesis):

Feet are 6 to 8 inches apart laterally, with prosthetic foot 6 to 8 inches forward.

Shift weight to normal leg.

Flex both prosthetic and normal knees, stoop, and place right hand on floor at position 4:00 o'clock.

Place left hand at 8:00 o'clock and lower body to floor.

(An amputee with a right prosthesis places the left hand on the floor first, in above exercise.)

*Rising* (Directions below are for left prosthesis):

Place right hand on floor at position of 4:00 o'clock.

Flex right leg with foot flat on floor.

Swing left hand across body and place in position of 1:00 o'clock. At the same time rotate body to right, bearing weight on right leg and hands.

Stand, bearing weight on normal leg.

Shift weight to prosthesis and step out on normal foot.

(An amputee with a right prosthesis follows the same directions as above, except that he pivots to the left, instead of the right.)

(12) *Back Step.*

*A/K and Tilting-table Amputees.* If backward steps are necessary, be sure they are short; never lift the feet from the floor. Keep legs straight and slide feet over floor.

*B/K Amputees.* Walk backward in the normal manner, lifting feet from floor.

(13) *Side Step.*

*Right Step:*

Shift weight to left side.

Abduct right leg and take side step, transferring weight to right leg.

Slide left foot over floor to position of normal stance and repeat exercise.

*Left Step:* Reverse procedure given above for right step.

(14) *Walking Up and Down Steep Incline.*

*A/K and Tilting-Table Amputees.* Go up sideways, with the normal leg nearest the top of the incline; or walk up diagonally, with the normal leg on the uphill side. Descend with normal leg nearest top of incline.

*B/K Amputees.* Walk up and down in the normal manner.

(15) *Curbs.*

*Step-Up.* Approach curb and place heel of prosthetic foot on it without looking down; keep knee completely extended. With a strong push-off, step on the curb with the normal foot. As skill develops, it is possible to learn to step up on curb with either foot. (Tilting-table amputees, however, of necessity place the normal leg on the curb first since there is no hip joint motion on the side of the amputation.)

*Step-Down.* Place prosthesis down first in stepping off a curb.

(16) *Proper Carriage of Prosthetic Foot.* A strongly recommended and practicable way of learning to carry the sole and heel of the foot as close to the floor as possible is the following "scraping-toe" exercise. Practice this exercise until the prosthesis can be controlled with the highest degree of proficiency.

Walk at normal walking speed, lightly scraping the toe of both the prosthetic foot and the normal foot, in turn, on the surface of the floor.

Immediately upon scraping the toe, place the heel upon the floor in such a position that both heels come in contact with an imaginary line 2 inches in width.

(17) *Development of Uniform Stride.* In performing the following exercise, keep the feet together and soles and heels as close to the floor as possible:

Walk slowly.

Look down and study the angles of both feet with relation to the floor as they are successively placed in forward position. If their stride is uniform, the angle of the prosthetic foot will be comparable to the angle of the normal foot. However, if the stride with the prosthesis is too long, the angle of that foot to the floor will exceed the angle of the normal foot.

In order to walk slowly and keep the sole of the prosthetic foot close to the floor, the stride with the prosthesis must be shortened to a point where it will duplicate the stride of the normal foot.

This exercise should be practiced 15 minutes a day until a uniform stride has been developed and all of the foregoing exercises can be performed with a fair degree of proficiency. Then the amputee can be graduated to the Advanced Class.

*c.* Music. Music may prove beneficial in developing rhythm and relaxation in walking if records are carefully selected.

*d.* Photography. At the completion of this class, motion pictures should be taken of each amputee's walking form.

## 41. Advanced Class

*a.* Objectives. In this class, walking technique should be perfected. With this as a goal, the instructor and amputee will view together the motion pictures taken at the end of the Intermediate Class (and any other pictures which may have been taken). The instructor will point out errors and outline the amputee's advanced training accordingly.

Faults to be corrected are:

(1) *Walking.*
Stepping off with prosthesis first.
Limp of any type.
Abduction of the stump.
Lifting prosthetic foot too high from floor.
Placing feet too far apart during walking stride.
Lateral pelvic motion.
Rigid walking posture.

(2) *Awkward Turns.*

(3) *Stairs.*
Inability to descend steps without aid of railing.
Improper placement of prosthetic foot on step.

*b.* Exercises. The following check exercises should be given at the beginning of this class (these exercises should not be required of tilting table amputees):

(1) *Check I* (to determine walking balance):
Walk at normal speed.
Stop at command of instructor and balance on the leg which is bearing the body weight at the time.
Inability to perform this exercise is the result of improper placement of the feet during the walking stride and hence unequal distribution of body weight.

(2) *Check II* (to determine efficiency of control over prosthesis):
Walk at normal speed, conforming to the fundamentals of good walking technique set forth in paragraph 37.
Scrape the toe of the prosthesis on command.
Above exercise should be practiced until it can be accomplished successfully.

*c.* Requirements for Discharge from Advanced Class.

(1) Proper walking balance with no detectable fault in gait.

(2) Walking with soles and heels as close to the floor as possible.

(3) Uniform stride.

(4) Walking with ease, arms swinging freely.

(5) Passing achievement test. (See table III.)

## Section III. TILTING-TABLE AMPUTEES

### 42. Exercise Program

As explained in paragraph 38, the exercises for tilting-table amputees are, in general, the same as those described for unilateral A/K amputees in paragraphs 39 through 41. Obviously, the tilting-table prosthesis presents special problems in control and balance which may require modification of the program for individual cases.

Paragraphs 43 through 45 describe problems of walking, sitting, and rising which are peculiar to tilting-table amputees because of the mechanics of the prosthesis.

### 43. Walking

The technique is the same employed by A/K amputees except for the following points:

*a.* Since there is no movement of the prosthesis at the hip joint, forward flexion of the entire prosthetic leg is produced by a movement of quick flexion of the pelvis, rather than by "hiking" the hip and extending the trunk on the pelvis. The last two movements are commonly seen, but result in an ungainly, awkward gait.

*b.* The normal leg of tilting-table amputees tends to take a longer stride than the prosthetic leg, contrary to the case of A/K amputees. This is because of the anatomical and mechanical difficulties in bringing the prosthesis forward in a long step.

*c.* After a patient acquires skill in controlling his prosthesis, he is permitted to unlock the knee, so that knee flexion is possible (assuming that the knee is mechanically arranged for flexion in walking). Walking with knee motion contributes materially toward a more normal appearing gait.

### 44. Sitting

Unlocking the hip and knee joints must be incorporated into the technique used by A/K amputees. The knee joint is unlocked first, when the patient has turned and is ready to sit. The weight is then shifted to the normal leg, the hip of the prosthesis is unlocked, and the patient sits down, still bearing his weight on the normal leg. The technique should be practiced until the patient unlocks the prosthesis automatically.

### 45. Rising

The weight is borne on the normal leg. As the patient assumes the erect position, the hip joint locks automatically. The knee is then locked normally, the weight is transferred to the prosthesis, and the patient steps forward with his normal leg.

## 46. General

The problem of learning to balance is more difficult for the bilateral amputee than for any other type of amputee because he has no normal leg upon which to support himself.

In general, the B/K bilateral amputee is taught the same walking techniques used by unilateral A/K amputees; however, variations may be necessary to meet individual needs.

## 47. Beginners Class

*a.* OBJECTIVES. The exercises in *b* below are designed to develop a sense of balance and should be continued until the patient can walk with the support of canes. Then he is ready for the Intermediate Class.

*b.* EXERCISES. Patients who take these exercises with pylons must repeat the routine upon acquiring full length prostheses.

(1) *Balance Exercise VI—Between Parallel Bars.*
Stand with feet as close together as possible.
Tighten abdominal muscles to correct anterior pelvic tilt.
Shift body weight laterally over one prosthesis, then over the other.
Keep the body in good postural alignment.

*Note.* "Pelvic roll," as such, is not desired because it is almost always accompanied by a marked feeling of instability of the knees.

(2) *Balance Exercise VII—Between Parallel Bars.*
*A/K Amputees:*
Stand with feet no more than 6 inches apart, if possible.
Hold pelvis in correct alignment.
Bear weight on one prosthesis, flex opposite thigh, and bring second prosthesis forward.
Shift weight to second prosthesis and hold briefly.
Then assume original position by bringing first prosthesis forward.
Repeat exercise, alternating prostheses.

*Tilting-Table Amputees* (with disarticulation). Follow above directions, alternating prostheses, but walk forward. (This will provide the momentum necessary for walking with tilting-table prostheses.)

(3) *Walking Exercise I—Between Parallel Bars.*
Stand with feet no more than 6 inches apart, if possible; and with hands on bars.
Shift body weight to right prosthesis and left arm and hand.
Advance left prosthesis and right hand.
Shift weight to left prosthesis, advancing right prosthesis.
Continue moving forward.

## 48. Intermediate Class

*a.* Objectives. Amputees should acquire the technique of walking with canes and of encountering ordinary obstacles.

When a patient has developed a uniform stride, is walking with all of his weight on the prostheses, and can perform the exercises in *b* below with a fair degree of proficiency, he progresses to the Advanced Class.

At the completion of this class, 100 feet of motion picture film is taken of each amputee's walking form.

*b.* Exercises. (1) *Walking Exercise I.* Follow directions in paragraph 47*b*(3), using two canes. Do not support all of the body weight on the canes or walk with canes ahead of the body. Try to get into the habit of swinging the arms as the walking technique improves.

(2) *Sitting and Rising from Chair.* The following directions are for the A/K amputee; however, a patient with disarticulation uses the same technique, making sure the hip is unlocked.

*Sitting:*

Approach chair from side.
Turn trunk and face chair.
Place one hand on back of chair and the other on the arm or seat of the chair.
Shift body weight to arms; flex hips, and swing into chair.

*Rising:*

Place right hand on the back, arm, or seat of chair (using position which feels most stable).
Place left hand on arm of chair (if cane is used, place well forward).
Extend left leg and lock knee in extension; raise body out of chair, bearing weight on hands and on left prosthesis.
Turning body toward right side, thrust weight over left prosthesis.
Extend and lock right prosthesis.
(It makes no difference whether the right or left prosthesis is extended first in rising, as long as the same sequence of events is followed.)

(3) *Turns.* An A/K amputee or a patient with hip disarticulation can make no pivots. Instead, he must move one leg laterally pivoting on the heel slightly, and then bring the second leg toward it; or he must walk in a small circle.

(4) *Stairs.*

*Ascending:*

(*a*) *A/K Amputee* (assuming left railing is used).
Place left hand and forearm on rail, and right hand on cane.
Place foot of left prosthesis on step.
Pull weight over left prosthesis by pushing off with cane and pulling up on rail.
Bring right foot to position beside left foot.

An alternate method is to—

Stand facing railing.

Place hands on railing.

Swing left (right) foot up on step and lock knee.

Pull upon railing and swing right (left) foot back and up on step behind the first foot, assuming stride position; and lock knee.

Rock back on right (left) foot and swing the other foot to the next higher step.

Continue up steps.

(*b*) *Bilateral Tilting-Table Amputee.*

Place one hand on railing and other hand on cane.

Put weight on hands, extend elbows and, at the same time, swing prostheses through to step.

*Descending* (the more advanced walkers may be taught to descend stairs facing in forward position):

(*a*) *A/K Amputee.*

*Using one railing and one cane; or, if the steps are wide, using two canes:*

Place left (right) hand on railing and right (left) hand on cane.

Lower cane to step and grasp rail.

Place heel *only* of left (right) foot on edge of step so that the knee will break. At the same time, lower the locked prosthesis to the next step, beside the cane. (The knee of the left (right) prosthesis should break simultaneously with the placing of the right (left) heel on the edge of the next lower step.)

*Using two canes:*

Lower left (right) cane to step below and place left (right) heel on edge of step from which descending.

Lower right (left) foot to step below, carrying weight on left (right) cane.

Lower left (right) foot and right (left) cane.

*Note.* The two techniques which follow are less stable, but practicable:

Lower left (right) cane and left (right) foot together; then right (left) cane and right (left) foot together.

Lower both canes together and swing feet to lower step.

(*b*) *Amputee with Tilting Table Prostheses.*

Place both hands on railing.

Extend elbows to lift body weight; at the same time swing prostheses to lower step.

(*c*) *Amputee with One A/K Prosthesis and One Tilting Table Prosthesis.* Descend as in (*a*) above, but lower tilting table prosthesis first.

(*d*) *Amputee with One B/K Prosthesis and One Tilting Table Prosthesis.* Descend as in (*a*) above, but lower tilting table prosthesis first.

(5) *Walking the Ramp.* In order to maintain balance, shorten the stride proportionately to the angle of the incline.

Use the same technique for breaking the knee as unilateral A/K amputees use in descending steps alternately, as required by the Intermediate Class exercise, Steps. (See par. 40*b*(7).)

(6) *Sitting and Rising from Floor.*

*Sitting:*

Stand with feet apart and bend at the waist until the fingers almost touch the floor.

Walk forward on hands to a point where it is possible to pivot to a sitting position.

*Rising:*

Lock knees.

Using one heel as a pivot, cross other leg over and turn 180°.

Take weight on hands and side of pivot foot.

Walk back on hands until hips are flexed to more than 90°.

Come to standing position with aid of cane.

*Note.* This technique is not recommended for patients with bilateral disarticulation.

## 49. Advanced Class

*a.* Objectives. Walking technique should be perfected to the point where the amputee no longer feels completely dependent upon his canes even though he continues to carry them for reasons of security. With this as a goal, the amputee and instructor view together the motion pictures taken at the end of the Intermediate Class. The instructor points out errors and outlines advanced training accordingly.

Faults to be corrected are:

(1) Abduction of stump.
(2) Lifting feet too high from the floor.
(3) Placing feet too far apart during walking stride.
(4) Lateral pelvic motion.
(5) Rigid walking posture.

*b.* Requirements for Discharge from Advanced Class.

(1) Proper walking balance with no detectable limp or lateral motion.
(2) Walking with soles and heels as close to the floor as possible.
(3) Uniform stride.
(4) Walking relaxed, with arms swinging freely.

# CHAPTER 6

# CAUSES AND CORRECTION OF LIMPS

## 50. Recognition of Limps

Certain factors influence the motion of a step, causing an awkward gait. Other factors influence the *weight-bearing* phases of the step, with resultant body "lists" and changes in the level of the pelvis laterally.

Types of limps are best distinguished in relation to the component parts of a step. If a step were broken down by slow motion, four important parts could be recognized:

*a.* Weight bearing on the prosthesis.
*b.* Motion of step with normal leg.
*c.* Weight bearing on normal leg.
*d.* Motion of step with prosthesis.

(Actually *a* and *b* above occur simultaneously, as do *c* and *d*. However, for the purpose of determining the defect which is responsible for a patient's walking difficulty, each component should be considered separately.)

## 51. Analysis of Limps (A/K Unilateral Amputees)

The following chart is used by instructor to determine causes of limps and means of correcting defects:

| Limp | Probable causes | Explanation of gait | Tests to determine cause accurately | Correction |
|---|---|---|---|---|
| *a.* ABDUCTION OF PROSTHESIS IN MOTION. | (1) Contraction of hip abductors on stump side. | Contraction of the abductors necessarily causes abduction of leg during forward motion of step with prosthesis. | Test for degree of hip abduction contracture. | Exercises for stretching out contracture in hip abductors on stump side. |
| | (2) Crotch pressure. | Patient abducts prosthetic leg in motion to relieve crotch pressure. | (*a*) Observe areas of redness on the upper inner part of the thigh following attempts at walking. Note presence of roll of flesh over inner flange of prosthesis and presence of sebaceous adenites.<br>(*b*) Have patient stand with weight on prosthesis.<br>(*c*) Have patient stand with body weight inclined forward (to increase the pressure on anterior crotch), balancing by holding on to stall bars, bars, or chair.<br>Patient will complain of pain due to pressure in tests (*b*) and (*c*) above. | Checking for fit of socket and alignment of prosthesis. |

| Limp | Probable causes | Explanation of gait | Tests to determine cause accurately | Correction |
|---|---|---|---|---|
| | (3) Weakness in gluteus medius on normal leg. | Weak gluteus medius on normal leg causes pelvis to tilt down toward opposite side during weight bearing on normal leg. This pelvic tilt creates an apparent lengthening of the prosthetic leg; in order to raise leg from floor, patient must abduct it. | Test for strength of gluteus medius on normal leg (isolating the posterior portion). | (*a*) Checking length of legs by height of anterior superior iliac spines to determine whether prosthesis is shorter and, hence, causing a constant weight-bearing strain on normal leg gluteus medius.<br>(*b*) Checking for advisability of inner border wedge on heel or Thomas heel on shoe of normal foot.<br>(*c*) Special exercises for normal leg gluteus medius—indicated only if the muscle is not subjected to weight-bearing strain. |
| | (4) Weakness of lower anterior abdominal muscles (particularly if in association with low back and hip flexor contracture). | Lack of anterior pelvic fixation throws an excessive load on hip flexors in performing the forward motion of step with prosthesis. If, in addition to the abdominal weakness, the hip flexor muscles are contracted to the extent that their range of action is very limited, | (*a*) Test for strength of lower anterior abdominal muscles.<br>(*b*) Test for contractures in hip flexor and low back muscles. | Special exercise to strengthen the lower anterior abdominals; and to stretch out the tight low back and hip flexor muscles in order to reestablish free range of motion of pelvis in relation to femur and lumbar spine. |

| | | | |
|---|---|---|---|
| | the patient cannot raise the leg forward sufficiently to lift the foot from the floor. Patients tend to substitute by using lateral abductor muscles to raise foot from floor. | | |
| (5) Fear of knee buckling. | Patient may be afraid that he will not be able to extend the knee after "breaking" it in the forward motion of a step. As a result he keeps the knee straight and abducts the leg to bring it forward. He may also fear that the toe will catch and prevent extension of the leg. | Test to rule out other causes of abduction (as listed above). | (*a*) Practicing correct balance and fundamental walking techniques.<br>(*b*) Developing reassurance. |

| Limp | Probable causes | Explanation of gait | Tests to determine cause accurately | Correction |
|---|---|---|---|---|
| *b.* WEIGHT ON PROSTHESIS: PELVIC DROP DOWN ON SIDE OF PROSTHESIS. | (1) Weakness of hip adductors on stump. | Stump adductor weakness is frequently mentioned as a cause of abduction of prosthesis in motion. Actually adductor weakness does not cause such abduction, because the thigh can be carried in the forward plane by the hip flexors despite such weakness. However, the effect of adductor weakness becomes apparent in the phase of weightbearing on the prosthesis; the stabilizing effect which these muscles normally give in fixing the pelvis to the thigh is lost and the pelvis shifts with a drop on the side of prosthesis. | Test for strength of stump adductors. | Exercises for stump adductors. |
| | (2) Prosthesis too short. | Pelvis drops on side of prosthesis as in cases of short leg. | Measure length of prosthesis while patient is standing with weight evenly distributed on both feet. | Lengthening of prosthesis at direction of responsible medical officer. |
| | (3) Stump sinks into prosthesis in weighting. | Prosthesis may be fitted for ischial weightbearing; but if pelvis tilts in walking, the ischium sepa- | To detect an up and down motion, place hand between ischial tuberosity and socket while patient stands | (*a*) Checking with responsible medical officer regarding fit of prosthesis.<br>(*b*) Checking for advisability |

| | | | | |
|---|---|---|---|---|
| | | rates from point of contact with prosthesis and allows a "piston action" of the stump in the prosthesis. (*Note.* A slight "piston action" is normal.) | and transfers weight from one foot to the other. | of additional stump socks.<br>(*c*) If prosthesis cannot be corrected, patient should consciously tense muscles of stump just before taking weight on prosthesis. This muscle "setting" tends to lessen tendency of stump to sink down into the prosthesis. |
| | (4) Abduction contracture of stump. | Contracture of the abductors places a strain on the adductors with resultant lack of fixation of the thigh to the pelvis as in actual adductor weakness. Pelvis shifts with drop on side of the prosthesis. | Test for contracture of abductors on stump side. | Exercises for stretching thigh abductors. |
| *c.* WEIGHT ON PROSTHESIS: PELVIC DROP DOWN TOWARD SIDE OF NORMAL LEG. | Stump abductor weakness. | Lack of sufficient lateral fixation between pelvis and femur causes wider separation of attachment at this point, as demonstrated by the tilt of pelvis down on the opposite side in a standing position. | Test strength of abductors on stump side. | Exercises to strengthen stump abductors. |

| Limp | Probable causes | Explanation of gait | Tests to determine cause accurately | Correction |
|---|---|---|---|---|
| *d.* WEIGHT ON NORMAL LEG: PELVIC DROP DOWN ON SIDE OF PROSTHESIS. | Abductor (particularly gluteus medius) weakness on normal leg. | See explanation of pelvic drop under *a*(3) above. | (*a*) Test strength of gluteus medius on normal leg.<br>(*b*) Test for balance with weight on normal leg, while patient is holding pelvis level. | (*a*) See *a*(3) above.<br>(*b*) Practicing balance on normal leg. |
| *e.* WEIGHT ON PROSTHESIS: UPPER TRUNK "SINKING" DOWN TOWARD SIDE OF PROSTHESIS (fig. 21 ②). | (1) Short stump.<br>(2) Generalized weakness of stump muscles, particularly abductors or adductors. | This trunk motion tends to "lock" the upper trunk on the pelvis, and the pelvis on the amputated extremity, in order to compensate for instability at the hip joint. | Test strength of all stump muscles. | (*a*) Exercises for strengthening stump muscles.<br>(*b*) If stump is too short to produce effective leverage on the prosthesis, the limp will be difficult to correct. Work to correct faults of body mechanics generally so that best balance is achieved with least muscular effort. |
| *f.* WEIGHT ON NORMAL LEG: RISING ON TOES OF NORMAL FOOT AT THE BEGINNING OF FORWARD MOTION OF PROSTHESIS. | Usually a substitute gait to avoid leg abduction or to overcome difficulty in raising prosthesis forward in step. | Rising on toes of normal foot "suspends" the prosthesis and makes it easy for prosthesis to swing through in the forward motion of a step. This creates an up and down motion of body. Such a gait is common for patients with thigh stumps shorter than 6 inches. | Check to determine defects in muscle action which make it difficult to raise prosthesis from floor and bring it forward. | Correction of any muscle defects and instruction in correct walking, with emphasis on pelvic flexion. |

| | | | | |
|---|---|---|---|---|
| *g.* TRANSFER OF WEIGHT ONTO PROSTHESIS: TRUNK INCLINED FORWARD AS KNEE EXTENDS. | Fear of knee buckling plus weakness or poor functional use of hip extensors. | The gait resembles that of a patient with residual quadriceps paralysis following anterior poliomyelitis. The body is inclined forward to force the knee backward in extension.<br>A prosthetic knee which must be forced into hyperextension for stability of the artificial leg will produce the same gait. | (*a*) Test strength of hip extensors.<br>(*b*) Check knee of prosthesis for hyperextension. | General correction of body and prosthesis mechanics. |
| *h.* BODY "BOBBING UP AND DOWN." | Too long a step with prosthesis. | If the stride is longer on one side, the body drops in height with each step on that side. There is a temptation to lengthen the forward stride with the prosthesis because this makes the normal leg maintain weight and balance for a longer time. Note distinction between this defect and that of *f* above. | (*a*) Have patient walk with equal length stride for both legs.<br>(*b*) Rule out drop due to stump sinking into prosthesis. | This limp is purely functional—not due to defect in body mechanics. Patient should shorten stride. |

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